PRECISE 1D DYNAMICAL ANALYSIS OF TEMPERATURE IN AN OIL-HYDRAULIC CYLINDER CHAMBER BASED ON 3D INTERNAL FLOW ANALYSIS

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Recently oil-hydraulic components have become smaller, that means small heat volume and small surface. Furthermore, the system pressure of an oil-hydraulic circuit is high. They often make the temperature of working oil and components rise up in case of heavily loading and long operation. Their high temperature in an oil-hydraulic system is dangerous and should be avoided. From this viewpoint, it is useful to establish any simple and precise way to predict the system temperature rise at the design stage.

Numerical prediction of temperature profile needs to calculate heat transfer, heat generation, and heat dissipation occurring in an oil passage, in a cylinder, in a valve, and in a tank in the oil-hydraulic circuit. 1D calculation of system dynamics usually spends a short time and it is convenient for dynamical design of a circuit. There are a few papers studying 1D prediction of temperature change by calculating heat generation and heat transfer in an oil-hydraulic system. However, they calculated dynamical heat balance by considering only effects of oil pipes. On the other hand, 3D numerical thermal and flow analysis has been performed popularly using commercial codes. However, 3D numerical analysis needs so many grids and so much time for calculation that it is much time-consuming. Especially, numerical analysis of system dynamics using 3D CFD codes is much time-consuming and not practical because of very small time step for calculating.

In the present paper, 1D modeling and simulation method to predict dynamical change of temperature in a cylinder chamber has studied by considering heat balance including the effect of volume change using numerical results calculated by 3D internal flow analysis. The internal flow in the oil-hydraulic cylinder chamber can be separated into two flow regions,

such as 3D and 1D flow pattern regions, as shown in Fig. 1. When the distance x separating the two regions can be located suitably in 1D modeling and simulation as a lumped parameter system, good simulation result is obtained on condition that the 3D flow pattern region should be set as a lump. In the simulation result, 1D profile of temperature agrees well with that averaged in the cross section of the chamber obtained in 3D calculation using a commercial code. The discussions include the followings; (1) a proposal to predict 1D profile of temperature in a cylinder chamber and verification of its availability, (2) an influence of number of separation in 1D lumped parameter model on the predicting precision, (3) generalization of 1D modeling of cylinder based on directional non-dimensional analysis way.

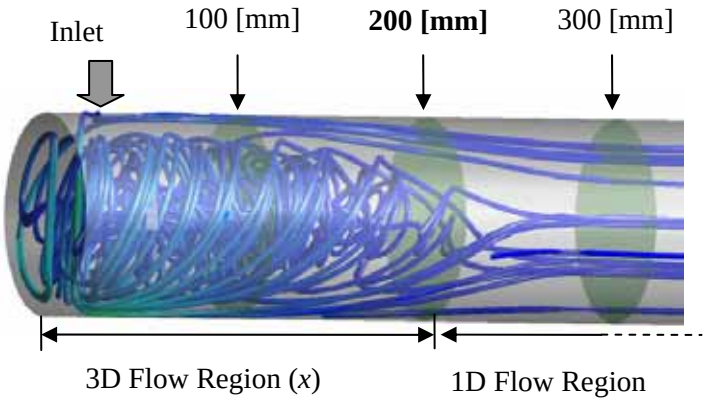

Fig. 1 Streamlines at Cylinder Chamber by 3D CFD code

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